Spatial and Temporal Comparisons of Shoreline Biota in South Puget Sound

EXECUTIVE SUMMARY

Groups as diverse as natural resource agencies, local governments, private landowners, and shoreline developers have a stake in the marine habitats and natural resources of Puget Sound. Information needs about the Sound are similarly diverse, but all can benefit from a comprehensive and detailed map of shoreline and nearshore habitats, and from information on changes seen through time. At present, no such detailed map exists, and gathering this level of information for this large an area is daunting. The Department of Natural Resources Aquatic Resources group has been refining and testing a method for gathering such habitat information in a cost-effective yet detailed manner. This methodology is called SCALE (Shoreline Classification and Landscape Extrapolation). At its core is the fact that most marine organisms, including seaweeds, seagrass, invertebrates, and fishes are linked rather tightly to their physical environment, including such factors as salinity, wave or current regime, and substrate type (i.e. rock versus sand versus mud). Thus detailed mapping of the physical habitats in an area should provide us with information on the biota inhabiting (or potentially inhabiting) that area. If the physical habitats in an area are mapped and then a random subset of each habitat type is studied in detail, describing its flora and fauna, then the data on those organisms can be inferred to other habitats of that same type in that region.

This model has now been tested on rocky shores of San Juan Island, on the Olympic coast of Washington, and most extensively in the soft sediments of Carr Inlet in south Puget Sound. Physical data in a region is gathered in a hierarchical fashion. First, data on oceanographic conditions (salinity, temperature, wave regime, etc.) are gathered for a coarse-scale division of a region into nearshore "cells" that differ in these key parameters (thus Carr Inlet, for example, was divided into 4 sections or cells). Then for regions where detailed mapping is desired, the shoreline of each cell is divided into linear units (segments), each of which is physically homogenous (i.e., similar substrate size, slope, wave energy, etc.). Carr Inlet was divided into 310 segments. This information is gathered by walking the shoreline of concern. A statistical clustering methodology is then applied to the data, to show which beach segments (within a cell) are the same according to these physical parameters. According to the model, these similar segments should also contain similar organisms, but should be different from segments in the same cell with finer substrate, and different from segments in another cell even if the substrate is the same.

Testing of this model in Carr Inlet in 1997 showed that, as predicted, organisms in the intertidal zone are tightly linked to physical features of the beach. Despite the rather high normal level of patchiness or variability of marine organisms seen at numerous scales, the plants and animals in similar segments within a cell tended to be very similar, but quite different from those in different segments and in different cells. Our initial study, however, did not allow us to answer 3 subsequent, critical questions: 1) Does the model really allow extrapolation about the character of the organisms in beaches that were not sampled as part of the original test? 2) How consistent are the biota in a given beach from year to year? If

there was a human-caused change, would we be able to distinguish it from natural variation? 3) How well can we extrapolate the character of the biota from Carr Inlet to elsewhere in Puget Sound, e.g. to nearby Case Inlet and a more distant one such as Budd Inlet\)? Our 1998 research addressed these questions.

To test the ability of the model to extrapolate to unsampled beaches in Carr Inlet, we randomly chose 3 new muddy beaches and 3 new sandy beaches that were physically similar to those sampled in 1997, including being in the same oceanographic cell. In each case, the biota of the new beaches were very similar (statistically indistinguishable) to those from the beaches already sampled, despite the fact that some of them are at considerable distance from each other. Thus the predictive value of SCALE, at the within-cell level, has been demonstrated. A potential practical application of this result is that if there were some localized event, such as an oil spill, that impacted just a few beaches in an inlet, the effects of that spill could be assessed via detailed sampling of physically matched but unimpacted beaches within the same oceanographic cell; these data would illustrate (with high statistical confidence) the biota that should have been there before the spill.

Temporal (annual) variability within beaches was assessed by resampling the biota of 3 mud, 3 sand, and 3 cobble beaches in Carr Inlet. None of these showed changes in measured physical characteristics over the intervening year. The biotic data showed that for each habitat type there were some changes in flora and fauna between the two years; this change was statistically significant for the cobble habitats, and less pronounced in the other two. In most cases, all the beaches shifted in the same "direction", i.e. there were shifts in the dominance of one species over another that were reflected in all three replicates for that habitat type. These data suggest that the organisms were responding to an environmental shift occurring at scales large enough to encompass all the segments sampled. Such shifts might comprise a major recruitment throughout the bay of a key species, or a series of storms that affected many organisms, or an effect of the El Nino that was impacting the Sound in 1997 but not in 1998.

There are several practical implications of this result; first, since temporal variation (on the scales of days, seasons, or years) is likely to occur at any given beach, sampling only one site will not allow us to distinguish real long-term change from random variation (unless the change is catastrophic). But if replicate sites are monitored through time and if similar changes are seen in all beaches, then this constitutes a strong signal that change is occurring (e.g., in response to increased armoring of the shore, or global warming). Second, in the case of a localized oil spill as described above, it would be misleading to rely on data gathered at that site in a previous year to assess what was expected to be there in the spill year. Only comparing replicate sites within that same year will allow unambiguous interpretation of differences seen at the spill site.

A potential avenue for future research is to extend the SCALE concepts and link the abundance of higher taxa to shoreline productivity. The first step would be to consider the effect of broader marine and terrestrial physical environments and prey resources on the behavior and diets of high priority fish and wildlife.

Note: Only the Executive Summary of this report is available on the web. For a complete copy of this report, contact the Nearshore Habitat Program .